Technology and Innovation at Johnson Space Center

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NASA is committed to keeping the United States at the forefront of human space exploration. In 2011, the agency released its strategic plan. One of the strategic goals calls for the creation of innovative new space technologies for exploration, science, and economic security.

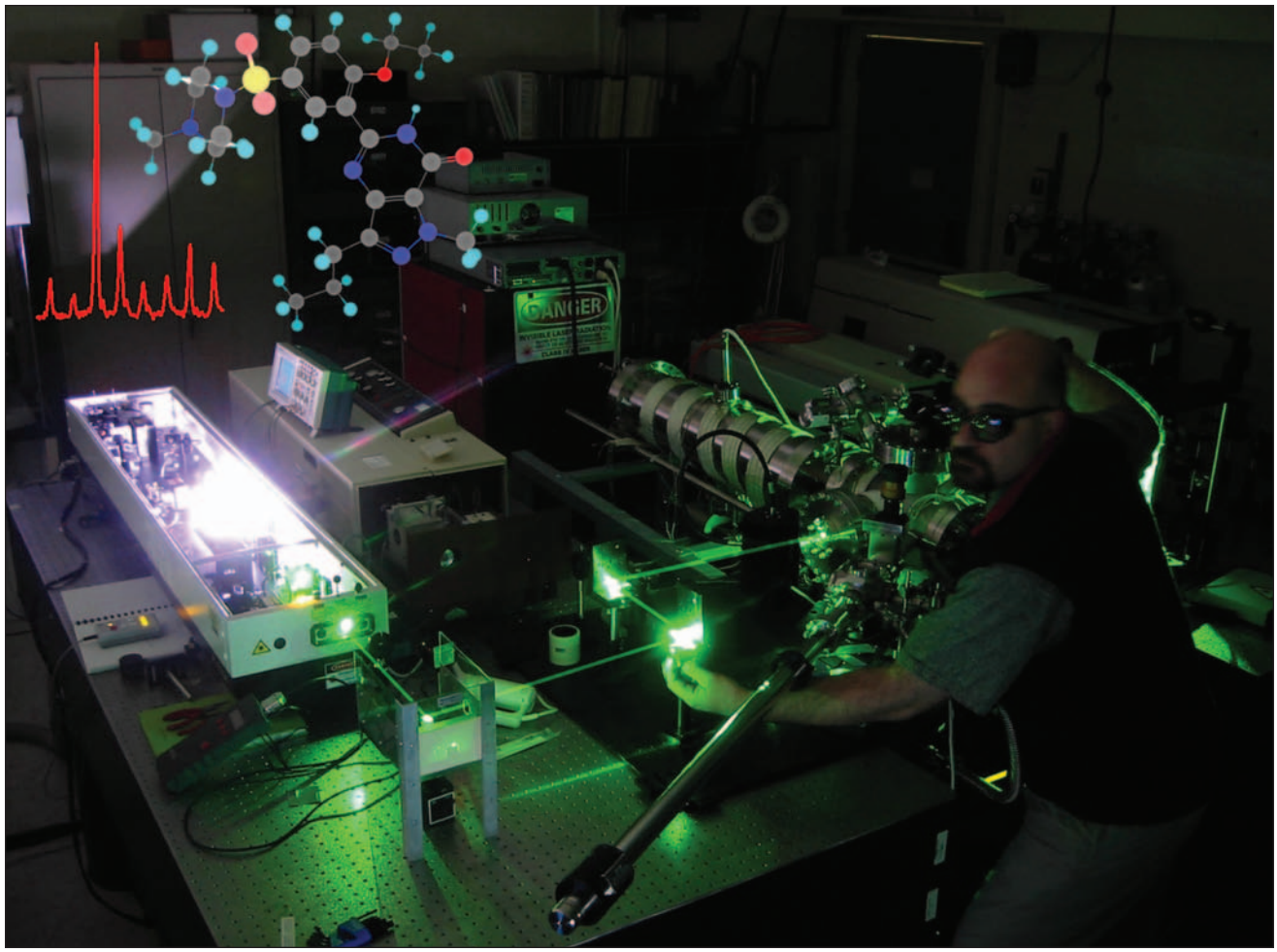
NASA's chief technologist serves as the NASA administrator's principal advisor and advocate on matters concerning agency-wide technology policy and programs. The Office of the Chief Technologist is responsible for direct management of NASA's Space Technology programs and for coordination and tracking of all technology investments across the agency. The office also serves as the NASA technology point of entry and contact with other government agencies, academia, and the commercial aerospace community. The office is responsible for developing and executing innovative technology partnerships, technology transfer, and commercial activities, and for the development of collaboration models for NASA. This office has also developed NASA's integrated technology roadmap to show how these technologies can contribute to NASA's missions and significant national needs (page xx). The keystone of that vision is effective and coordinated management technology development and innovation from Headquarters through each NASA field center resulting in leading-edge missions of the future. The field centers have been charged with providing technologies that support both national needs and human space exploration.

The chief technologist at Johnson Space Center (JSC) works closely with JSC's senior scientists, technologists, and managers to optimize available resources, select appropriate technologies, and manage a portfolio of innovation and technology projects. Center technology portfolio management efforts are coordinated according to a strategy for center innovation and technology that is based on the following innovation and technology strategic themes:

1. Develop the human space flight workforce of tomorrow.
2. Invest and nurture core capabilities needed for the future.
3. Establish a consistent approach to guide future commitments.
4. Foster "integrative thinking."

With these strategic themes in mind, the JSC chief technologist has established a set of initiatives that represent JSC's commitment to develop new technologies related to NASA Strategic Goals. These initiatives include:

- Technology and Innovation *Projects*
  - *Center-Level Independent Research and Development* – Multi-year technology project fund series supports collaborations that assure silo-smashing integration needed for cross-cutting technologies in five priority topic areas including: 1. Technologies for Space Environment Protection; 2. Technology Enabling Planetary Science; 3. Space Healthcare Innovations; 4. Planetary Surface Operations; and 5. Energy and Propulsion Technologies.
  - *Directorate-Level Independent Research and Development* – Annual fund assigned directly to JSC's major research and development-producing organizations to maintain key technology area proficiencies needed to support future missions.
  - *Innovative Charge Account* – Provides numerous small dollar value awards for individuals to pursue ideas. More importantly, the intent for Innovative Charge Account is to create the innovation time recognized as vital to a center-wide environment of ingenuity and creativity.
- Technology and Innovation *Infrastructure*
  - *Innovation Facilities, Tools and Symposia* – There are a number of facilities (e.g., the Innovation Design Center) at JSC where the community can gather to develop ideas and plan. In addition, the chief technologist is working with a number of organizations to pilot test and deploy open innovation tools (e.g., NASA@Work) to leverage an empowered workforce with the creative energies in academia and industry. Their calendar includes a continuum of events (e.g., Innovation 2011, TEDx [Technology, Entertainment, Design] events, etc.) throughout the year with the



Johnson Space Center laser mass spectrometer being used for microscopic organic analysis.

intention of fostering creativity, and moving personnel outside of normal circles to expose the workforce to new ideas, issues, and perspectives.

- *Cadre of Innovators Pilot* – Induction of candidates for membership into an elite cadre that would be supported with additional resources to continue creating. The cadre would "give back" to the community by mentoring the younger talent at JSC and sharing their experiences at public schools and universities to encourage young minds to consider careers in science, technology, engineering, and mathematics.
- *Research and Technology Ambassador Assignments* – Provides a unique opportunity for JSC employees to benefit from "immersion experiences" to gain a full appreciation of innovative cultures outside of JSC, and for JSC to develop and maintain strategic partnerships, collaborations, and alliances that achieve our business objectives.

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continued

Successful achievement of these initiatives provides the catalyst for continued excellence in those capabilities that are the hallmark of JSC. Continued vigilance in maintenance of these competencies, capabilities, and the workforce skilled in their application is essential to remaining a world-class center for human space exploration.

JSC is committed to bringing the excitement and reward of innovation and technology to a growing community—ways that inspire new ideas, enthusiasm, and a desire to be part of a new era of human space exploration.

Relating the Johnson Space Center Innovation and Technology Initiatives to NASA Technology Roadmaps

JSC engineers and scientists are fully engaged in NASA's significant technology development efforts, and their contributions have relevance to the agency's goals. JSC has active research and technology initiatives (highlighted in red) in almost all of the areas depicted on the Space Technology Roadmap (right).

Space Technology Roadmaps—Technology Area Breakdown Structure

TA01 Launch Propulsion Systems

Solid Rocket Propulsion Systems
- Propellants
- Case Materials
- Nozzle Systems
- **Hybrid Rocket Propulsion Systems**
- Fundamental Solid Propulsion Technologies

Liquid Rocket Propulsion Systems
- LH_2/LOX Based
- RP/LOX Based
- **CH_4/LOX Based**
- Detonation Wave Engines (Closed Cycle)
- **Propellants**
- **Fundamental Liquid Propulsion Technologies**

Air Breathing Propulsion Systems
- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
- Ramjet/ Scramjet Engines (Accelerators)
- Deeply-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

Ancillary Propulsion Systems
- **Auxiliary Control Systems**
- **Main Propulsion Systems (Excluding Engines)**
- **Launch Abort Systems**
- **Thrust Vector Control Systems**
- **Health Management & Sensors**
- **Pyro & Separation Systems**
- **Fundamental Ancillary Propulsion Technologies**

Unconventional / Other Propulsion Systems
- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

TA02 In-Space Propulsion Technologies

Chemical Propulsion
- **Liquid Storable**
- **Liquid Cryogenic**
- Gels
- Solid
- Hybrid
- **Cold Gas/ Warm Gas**
- **Micro-propulsion**

Non-Chemical Propulsion
- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

Advanced (TRL <3) Propulsion Technologies
- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- **Breakthrough Propulsion**

Supporting Technologies
- **Engine Health Monitoring & Safety**
- **Propellant Storage & Transfer**
- Materials & Manufacturing Technologies
- Heat Rejection
- **Power**

TA03 Space Power & Energy Storage

Power Generation
- Energy Harvesting
- **Chemical (Fuel Cells, Heat Engines)**
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

Energy Storage
- **Batteries**
- Flywheels
- **Regenerative Fuel Cells**

Power Management & Distribution
- **FDIR**
- **Management & Control**
- **Distribution & Transmission**
- Wireless Power Transmission
- **Conversion & Regulation**

Cross Cutting Technology
- **Analytical Tools**
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

TA04 Robotics, TeleRobotics & Autonomous Systems

Sensing & Perception
- Stereo Vision
- LIDAR
- Proximity Sensing
- Sensing Non-Geometric Terrain Properties
- Estimating Terrain Mechanical Properties
- Tactile Sensing Arrays
- Gravity Sensors & Celestial Nav.
- **Terrain Relative Navigation**
- Real-time Self-calibrating of Hand-eye Systems

Mobility
- Simultaneous Localiz. & Mapping
- Hazard Detection Algorithms
- Active Illumination
- 3-D Path Planning w/ Uncertainty
- Long-life Extr. Enviro. Mechanisms
- **Robotic Jet Backpacks**
- Smart Tethers
- Robot Swarms
- Walking in Micro-g

Manipulation
- **Motion Planning Alg., High DOF**
- Sensing & Control
- Robot Arms (light, high strength)
- Dexterous Manipul., Robot Hands
- Sensor Fusion for Grasping
- Grasp Planning Algorithms Robotic Drilling Mechanisms
- Multi-arm / Finger Manipulation
- **Planning with Uncertainty**

Human-Systems Integration
- **Crew Decision Support Systems**
- **Immersive Visualization**
- **Distributed Collaboration**
- **Multi Agent Coordination**
- Haptic Displays
- Displaying Range Data to Humans

Autonomy
- Spacecraft Control Systems
- Vehicle Health, Prog/ Diag Systems
- Human Life Support Systems
- Planning/Scheduling Resources
- Operations
- **Integrated Systems Health Management**
- FDIR & Diagnosis
- System Monitoring & Prognosis
- V&V of Complex Adaptive Systems
- **Automated Software Generation**
- **Software Reliability**
- Semi Automatic Systems

Autonomous Rendezvous & Docking
- Rendezvous and Capture
- Low impact & Androgenous Docking Systems & Interfaces
- Relative Navigation Sensors
- Robust AR&D GN&C Algorithms & FSW
- Onboard Mission Manager
- AR&D Integration & Standardization

RTA Systems Engineering
- Human safety
- Refueling Interfaces & Assoc. Tools
- Modular/Serviceable Interfaces
- High Perf., Low Power Onboard Computers
- Environment Tolerance
- Thermal Control
- Robot-to-Suit Interfaces
- **Common Human-Robot Interfaces**
- Crew Self Sufficiency

TA05 Communication & Navigation

Optical Comm. & Navigation
- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

Radio Frequency Communications
- **Spectrum Efficient Technologies**
- Power Efficient Technologies
- **Propagation**
- **Flight & Ground Systems**
- Earth Launch & Reentry Comm.
- **Antennas**

Internetworking
- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

Position, Navigation, and Timing
- Timekeeping
- Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- **Relative & Proximity Navigation**
- Auto Precision Formation Flying
- **Auto Approach & Landing**

Integrated Technologies
- **Radio Systems**
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Nav. Sensors
- RF/Optical Hybrid Technology

Revolutionary Concepts
- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Navigation & Tracking
- Quantum Key Distribution
- Quantum Communications
- SQIF Microwave Amplifier
- Reconfigurable Large Apertures

TA06 Human Health, Life Support & Habitation Systems

Environmental Control & Life Support Systems & Habitation Systems
- **Air Revitalization**
- **Water Recovery & Management**
- Waste Management
- **Habitation**

Extravehicular Activity Systems
- **Pressure Garment**
- **Portable Life Support System**
- **Power, Avionics and Software**

Human Health & Performance
- **Medical Diagnosis/ Prognosis**
- **Long-Duration Health**
- **Behavioral Health & Performance**
- **Human Factors & Performance**

Environmental Monitoring, Safety & Emergency Response
- Sensors: Air, Water, Microbial, etc.
- Fire: Detection, Suppression
- Protective Clothing / Breathing
- **Remediation**

Radiation
- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Space Weather Prediction
- Monitoring Technology

TA07 Human Exploration Destination Systems

In-Situ Resource Utilization
- **Destination Reconnaissance, Prospecting, & Mapping**
- Resource Acquisition
- Consumables Production
- Manufacturing & Infrastructure Emplacement

Sustainability & Supportability
- Logistics Systems
- Maintenance Systems
- Repair Systems

"Advanced" Human Mobility Systems
- **EVA Mobility**
- Surface Mobility
- Off-Surface Mobility

"Advanced" Habitat Systems
- Integrated Habitat Systems
- **Habitat Evolution**

Mission Operations & Safety
- Crew Training
- Environmental Protection
- Remote Mission Operations
- Planetary Safety

Cross-Cutting Systems
- Modeling, Simulations & Destination Characterization
- Construction & Assembly
- Dust Prevention & Mitigation

TA08 Science Instruments, Observatories and Sensor Systems

Remote Sensing Instruments / Sensors
- Detectors & Focal Planes
- Electronics
- Optical Components
- Microwave / Radio
- Lasers
- Cryogenic / Thermal

Observatories
- Mirror Systems
- Structures & Antennas
- Distributed Aperture

In-Situ Instruments / Sensor
- Particles: Charged & Neutral
- Fields & Waves
- In-Situ

TA09 Entry, Descent & Landing Systems

Aeroassist & Atmospheric Entry
- **Rigid Thermal Protection Systems**
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators
- **Instrumentation & Health Monitoring**
- **Entry Modeling & Simulation**

Descent
- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion
- **GN&C Sensors**
- Descent Modeling & Simulation

Landing
- Touchdown Systems
- **Egress & Deployment Systems**
- Propulsion Systems
- **Large Body GN&C**
- Small Body Systems
- Landing Modeling & Simulation

Vehicle Systems Technology
- **Architecture Analyses**
- Separation Systems
- **System Integration & Analyses**
- Atmosphere & Surface Characterization

TA10 Nanotechnology

Engineered Materials & Structures
- Lightweight Structures
- Damage Tolerant Systems
- Coatings
- Adhesives
- Thermal Protection & Control

Energy Generation & Storage
- Energy Storage
- Energy Generation
- Energy Distribution

Propulsion
- **Propellants**
- Propulsion Components
- In-Space Propulsion

Sensors, Electronics & Devices
- Sensors & Actuators
- Nanoelectronics
- Miniature Instruments

TA11 Modeling, Simulation, Information Technology & Processing

Computing
- **Flight Computing**
- **Ground Computing**

Modeling
- **Software Modeling & Model-Checking**
- **Integrated Hardware & Software Modeling**
- **Human-System Performance Modeling**
- Science & Engineering Modeling
- **Frameworks, Languages, Tools & Standards**

Simulation
- **Distributed Simulation**
- **Integrated System Lifecycle Simulation**
- **Simulation-Based Systems Engineering**
- Simulation-Based Training & Decision Support Systems

Information Processing
- **Science, Engineering & Mission Data Lifecycle**
- Intelligent Data Understanding
- **Semantic Technologies**
- Collaborative Science & Engineering
- Advanced Mission Systems

TA12 Materials, Structures, Mechanical Systems & Manufacturing

Materials
- **Lightweight Structure**
- Computational Design
- Flexible Material Systems
- Environment
- Special Materials

Structures
- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainment
- **Test Tools & Methods**
- **Innovative, Multifunctional Concepts**

Mechanical Systems
- Deployables, Docking and Interfaces
- Mechanism Life Extension Systems
- Electro-mechanical, Mechanical & Micromechanisms
- **Design & Analysis Tools and Methods**
- Reliability / Life Assessment / Health Monitoring
- Certification Methods

Manufacturing
- **Manufacturing Processes**
- Intelligent Integrated Manufacturing and Cyber Physical Systems
- **Electronics & Optics Manufacturing Process**
- Sustainable Manufacturing

Cross-Cutting
- **Nondestructive Evaluation & Sensors**
- **Model-Based Certification & Sustainment Methods**
- **Loads and Environments**

TA13 Ground & Launch Systems Processing

Technologies to Optimize the Operational Life-Cycle
- Storage, Distribution & Conservation of Fluids
- Automated Alignment, Coupling, & Assembly Systems
- Autonomous Command & Control for Ground and Integrated Vehicle/ Ground Systems

Environmental and Green Technologies
- Corrosion Prevention, Detection, & Mitigation
- Environmental Remediation & Site Restoration
- Preservation of Natural Ecosystems
- Alternate Energy Prototypes

Technologies to Increase Reliability and Mission Availability
- Advanced Launch Technologies
- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

Technologies to Improve Mission Safety/Mission Risk
- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

TA14 Thermal Management Systems

Cryogenic Systems
- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

Thermal Control Systems
- Heat Acquisition
- Heat Transfer
- Heat Rejection & Energy Storage

Thermal Protection Systems
- **Entry / Ascent TPS**
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

TA15 Aeronautics

Aerosciences
- Propulsion Airframe Integration
- Drag Reduction
- Novel Configurations
- Propulsion Airframe Aeroacoustics
- Computational Methods
- Robust Aero
- Formation Flight
- Wake Vortex
- VSTOL/ESTOL
- Reduce/Mitigate Sonic Boom
- Multidisciplinary Design & Analysis Tools
- **Efficient Hypersonic Aero**

Propulsion and Power
- Quiet Propulsion
- Ultra-clean Propulsion & Alternative Fuels
- Fuel Efficiency
- Propulsion for STOL/ VTOL
- Supersonic Propulsion
- Combined Cycle Hypersonic
- Aero-Propulsion-Servo-Elasticity
- Robust Propulsion
- Hybrid Propulsion and Power
- Variable Cycle
- Alternative Engine Cycles
- Intelligent Engines
- Integrated Power Management

Dynamics, Control, Navigation, Guidance, and Avionics
- **Advanced Guidance**
- Distributed Decision, Uncertainty, & Flight Path
- Distrib Flow Contr. of Veh. Dyn.
- **Intelligent & Adaptive Control**
- Fault-Tolerant IVHM
- On-Board Weather
- **Pilot Vehicle Integration**
- Synthetic & Enhanced Vision
- UAV in the NAS
- Advanced V&V
- Load, Vibr. & Stability Control
- **Advanced Comm.**

Intelligent & Human Integrated Systems
- Complex Interactive Systems
- Separation Assurance
- Wake Vortex Systems
- Architecture Vulnerability Analysis for Air Traffic Control
- Air Traffic Control for Adverse Weather
- Collaborative Decision Systems
- Operational Maintenance Data
- Task & Attention Management
- Environmentally Friendly Aviation
- Super Density Operations